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MONTREAL HARBOR.

REPORT

OF THE

CHIEF ENGINEER,

OF THE

DEPARTMENT OF PUBLIC WORKS,

CANADA,

ON

THE ST. LAWRENCE BRIDGE AND MANUFACTURING COMPANY'S SCHEME, FOR PROPOSED WORKS.

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No. 6498

MONTREAL HARBOR

SHEARER SCHEME.

Ref. 20,531

DEPARTMENT OF PUBLIC WORKS.

CHIEF ENGINEER'S OFFICE,

OTTAWA, 19th March 1883.

F. H. Ennis, Esq., Secretary Depart. Public Works :

SIR,—I have the honor to submit, for the information of the Honorable the Minister, the following with reference to an application made to Parliament by the promoters of the Saint Lawrence Bridge and Manufacturing Company, commonly called the "Shearer Scheme," for powers to construct a dam or embankment across the St. Lawrence from Point St. Charles, at or near the abutment of the Victoria Bridge, to the head of St. Helen's Island, opposite Montreal; and a bridge across the channel between said island and the southern or St. Lambert's shore, the whole with the view of the creation of power for manufacturing purposes, and affording a means of transit for highway and railway traffic between the north and south sides of the river.

The embankment proposed is to contain three series (of ten each) of controlling sluices capable (so stated) of passing into the harbor 486 millions of cubic feet of water per hour. The control of these sluices, it is proposed by the promoters, shall be placed in the Board of Harbor Commissioners, and Mr. T. F. Bateman, the Engineer to the Company, (from whose report of the 18th January of 1882 I quote) states that they should be closed during the winter season, and opened only when required during the season of navigation, etc.

It is further proposed that the embankment shall contain 35 sluices for manufacturing purposes, capable of discharging into the harbor about 364 millions of cubic feet per hour, and these sluices are also to be generally superintended and controlled by the Harbor Commissioners.

The total flow of water into the harbor through these systems of sluices will amount to 850 millions of cubic feet per hour, or 236,111 cubic feet per second.

As this embankment will obstruct the present course of the river past Montreal, it is proposed, for the purpose of increasing the discharging power of the channel between St. Helen's Island and the St. Lambert shore, hereinafter called the South Channel,—to remove entirely Moffat's Island and its connexion with the shore, also all existing islets, rocky patches, and obstructions, and to widen and straighten it at the points colored *red* on the plan herewith, which is a reduction of the plan submitted by the promoters of the Company. It is further proposed to widen the passage between St. Helen's Island and Ile Ronde, to permit the passage of 85 millions of cubic feet per hour into the harbor, thus increasing its discharge to 935 millions of cubic feet per hour—exclusive of the discharge from the Lachine Canal.

This discharge of 935 millions of cubic feet per hour is equal to 259,722 cubic feet per second, and if to it be added the discharge per second from the Lachine Canal, viz., 2,288 cubic feet, the total discharge into the harbor of Montreal will be, according to Mr. Bateman, 262,010 cubic feet per second.

As the construction of the proposed embankment will entirely bar the passage of steamers and craft through the present and only channel, it is

proposed to excavate a channel along the southern side of St. Helen's Island, 300 feet in width, to an uniform depth of 10 feet below the present bed of the river, so that when the level of the harbor has to be maintained by keeping the whole of the sluices running full bore, there may be a sufficient depth through the South Channel for all purposes of navigation.

This project bears upon four interests, each of much importance, and having, in a degree, a connexion with each other.

1. The navigation of the St. Lawrence above Montreal.

2. Its effects upon the Harbor of Montreal.

3. Its effects upon the country on either side of the St. Lawrence to the foot of the Lachine Rapids.

4. Its effects upon the City of Montreal.

With respect to the navigation of the St. Lawrence above Montreal, it is claimed that, by clearing the South Channel of all obstructions, and excavating a deep channel as proposed, the boats now plying to Laprairie or descending the Lachine Rapids will not in any way be interfered with.

The only objection to this channel for vessels is that the distance between Montreal and Laprairie would be increased about 2½ or 3 miles on the round trip, thus making a little extra running for the steamers engaged in the ferry service, which is not a matter of vital importance.

The bridge proposed to be constructed across the South Channel should not be less in height above summer water level than the centre span of the Victoria Bridge.

The effects this embankment will have upon the future of the harbor of Montreal demand the most serious consideration.

This harbor is now capable of receiving the largest class of sea-going vessels, and has become perhaps the largest port of entry in the Dominion. All these results are due to the expenditure of a large amount of money, and the energy and determination of the business men of Montreal; and it becomes a question whether these business men, through their representatives, the Board of Harbor Commissioners, have not a vested

right in the harbor, a right which should not be disturbed, or if interfered with, then such interference should be with the view of doing as little harm as possible.

Now the promoters of the "Shearer Scheme" state that they will not interfere with the harbor, or the rights and privileges enjoyed by the Harbor Commissioners; that the works they propose will be of advantage to the harbor; that the level of the water will not be lowered, and can be controlled as regards height by the sluices before referred to; that the *detritus* annually brought into the harbor during the winter and times of spring freshets will be cut off; and that after the harbor is once dredged to its intended depth, it will not require any further attention, except to remove the sediment deposited from local causes; that the St. Mary's Current will be reduced in velocity from 8½ miles to 5 miles per hour; and that the rapid current between Ile Verte and Sous-le-Mont will be extinguished.

Attached to this communication is a report prepared by Mr. Thomas Guerin, C. E., of this Department, whose thorough knowledge of the science of hydraulics and long and practical experience render him in every way capable of investigating the question of interfering with the discharge of so great a river as the St. Lawrence, and of determining scientifically the probable results which may obtain from such interference as is proposed by the promoters of the "Shearer Scheme."

Mr. Guerin has for many months made a study of the river opposite Montreal, and the results of his investigations are given at full length; and he deals entirely with facts as they were found to exist, and not with opinions or suppositions, his attention being exclusively given to the elucidation of two questions:—

1. How the proposed scheme would affect the depth of water in the harbor; and

2. How it would affect the land on either side of the river.

With respect to the first question Mr. Guerin, assuming a certain date, has determined the flow of the river on that date, and shows that if the dam were then in existence, and all the sluices closed,

the whole of the water in the St. Lawrence would be forced through the South Channel, which would rise nearly 9 ft. in height, whilst the water in the harbor would—even allowing for any quantity that might back in through the Ile Ronde Channel—be reduced 3 feet below its usual level.

It may be pertinent here to state that it is considered to be low water in the harbor when there is a depth of 17 ft of water on the sill of Lock No. 1, Lachine Canal, and as the level of this sill is 81 ft. above datum, it follows that the elevation of low water is 98 feet above datum.

To restore this loss of 3 ft. or to raise the elevation from 95 to 98 ft., it becomes necessary to open the sluices, and the amount stated by Mr. Bateman, viz., 850 millions of cubic feet per hour, or 236,111 cubic feet per second is taken from the flow through the South Channel, which at the date assumed was passing 287,129 cubic feet per second, and stood 9 feet above the legitimate level of the harbor, or 12 feet above its reduced level; and this amount of 12 feet represents the head on the sluices at the time they are opened to supply the wants of the harbor. As before stated, the South Channel was passing 287,129 cubic feet per second, and at the moment the whole of the sluices are opened, they will pass 236,111 cubic feet per second, or a total of 523,240 cubic feet per second will be abstracted from the river, which will have the effect of quickly diminishing the depth in the South Channel, and this diminution of head will at once diminish the flow through the sluices as well, and both will proceed until an equality is obtained, or until the discharge of the St. Lawrence is equal to the discharge through the South Channel, *plus* the discharge into the harbor through the sluices, or when both are equal to a flow of 287,129 cubic feet per second.

Mr. Bateman states that he expects a quantity equal to 85 millions of cubic feet per hour to pass into the harbor through the Ile Ronde channel to assist in maintaining it at its normal level. Mr. Guerin does not permit this to enter into his calculations, because the velocity in the South Channel, its elevation above that of St. Mary's Current, the dimensions of the channel or passage between Ile Ronde and St. Helen's Island, the angle the current through it makes with St. Mary's Current, and the velocity of the latter,

are all functions in determining the quantity which would have a tendency to pass into the harbor.

Eliminating this quantity entirely, Mr. Guerin states that after the works have been completed, and all the sluices are running full, the level of the harbor of Montreal will be permanently reduced 0.80 ft., or 9½ inches; and he goes further and asserts that to maintain the harbor at this reduced level, the sluices once open *cannot* be closed again without diminishing the water in the harbor. The inference therefore is that the sluices, both for controlling and milling purposes, must remain fully open at all times during the season of navigation, and also that the permanence of this reduced elevation is entirely dependent upon the permanence and stability of the sluices themselves, and their freedom from damage, and liability to be choked or stopped up by *débris*, or even an odd boat or barge now and then, for it must not be forgotten that the velocity of the water passing through these sluices will range from 10 to 18 miles per hour; and the indraught will be sufficient to swamp anything unfortunate enough to be caught on the upper side of the dam; and for this reason it will be impossible to leave the sluices open during the winter season, as from their small dimensions they would most assuredly choke and be filled with ice.

The maintenance of the present depth in the harbor of Montreal, a depth obtained after many years of labor and at a great expense, is of paramount importance, and ought not to be made dependent upon the working of a few sluice gates in a dam. The interests involved in the harbor of Montreal are far and beyond any that can accrue to the promoters of the "Shearer Scheme," and these interests should be most jealously guarded and protected against any scheme or proposal which would in any way interfere with them, or in any way do damage to the harbor itself; nor should the construction of any works be permitted which would throw the *onus* of maintaining the harbor at its (reduced) normal level, upon the Harbor Commissioners, as is intended by the promoters where it is stated that the sluices *shall* be under their control; neither should there be a possibility created, that in the future, a large expenditure would be necessary to re-dredge over the harbor, to obtain a deeper depth of water, as most assuredly would be the case if the milling sluices were leased and shut up by mills and factories.

The next point for consideration is the effect the construction of this dam or embankment would have on lands on either side of the St. Lawrence.

With respect to this Mr. Bateman states that wherever it may be necessary a levee will be built along the course of the South Channel. This, however, will not be enough, as there is every probability that by the construction of this dam the periods of flooding will be more frequent; and the question arises whether this levee will not have to extend from Longueuil to the foot of the Lachine Rapids, and from Point St. Charles to the same point, and also be of such a height and dimensions as to be an inconvenience, if not a nuisance, to the occupiers of lands fronting on the river.

In treating upon the action of the St. Lawrence ice during the winter season, the ice becomes a principal factor, and the effects produced by it in the harbor of Montreal have been noted and commented upon by various observers, who all appear to have assumed the hypothesis expressed by Sir Wm. Logan some 40 years ago, to the effect that the rise of the water in the harbor in winter, is in consequence of the floating ice becoming jammed across St. Mary's Current. This hypothesis is disavowed by Mr. Guerin, who gives his reasons for doing so, and also enters fully into what may be considered the true solution of the winter phenomena in Montreal harbor, as well as in any river or stream in Canada.

Mr. Guerin states that this rising is due to the fact that when a river is frozen across, it partakes of the character of a tube, as the underside of the ice may be taken as equal in width to the bottom, or bed of the stream, and, therefore, the wetted perimeter having become doubled, the velocity is reduced in the proportion of $1 : \sqrt{2}$, or as $1 : 0.70$; or, the velocity, after the surface is frozen, will be $\frac{7}{10}$ that of the previous velocity. This reduced velocity also depends upon the comparative roughness of the underside of the ice, for, if it be greater than that of the bed of the river, then the velocity will be less than $\frac{7}{10}$ the previous velocity, and if smoother, the co-efficient will be greater. In proof of this Mr. Guerin submits a plan of the river in the vicinity of Moffat's Island, prepared for the Department under the directions of Mr. Harrington of the Lachine Canal Office, Montreal, during the winter of 1880, on which it is shown that the summer velocity in that locality was 7 miles per hour, and the winter velocity 3½ miles per hour,

showing that the co-efficient of velocity in the harbor is not $\frac{7}{10}$, but $\frac{5}{10}$ and he further states that he had obtained Mr. Harrington's notes of measurements made at the time of the survey, and their average would give a co-efficient somewhat less than $\frac{5}{10}$, but that he had adopted it in his calculations.

This reduced velocity is therefore the cause why the water in the harbor rises in the winter, which it must do to permit the volume of water brought from above to pass; for, to pass equal quantities of water where the velocity has been reduced one-half ($\frac{5}{10}$), it follows that the mean depth must be doubled.

Mr. Guerin proceeds to prove his statement, and shows that the elevation of the water in the harbor of Montreal after the ice had ceased to shove *this* winter, would be 110.22 feet above datum, or 12.22 feet above the level of the water on the 24th Nov., 1882, before the river had been frozen across, the mean depth on that day being 12.22 feet. He states that the paragraph containing this assertion was written on the 21st Dec., 1882, before the river had frozen across, and that its correctness could be verified in the future.

In proof of the correctness of this calculated height, I find it stated in the "Montreal Star" of the 2nd Jan., 1883, that the ice had jammed opposite Montreal, and the river in consequence had risen to 110.92 feet above datum, which is $\frac{7}{10}$ of a foot higher than calculated by Mr. Guerin.

The shoving of ice is due to the struggle on the part of a river to attain its normal state, that is—to pass its volume of water at the reduced velocity consequent upon the freezing of its surface, and this struggle will continue, resulting in ice packs and jams, until the whole body of ice is lifted to the required height; and when sufficient space is obtained to pass the quantity due to the average flow of the river and the quantity which had accumulated due to the delay in lifting the whole body of the ice below, then an equilibrium is established, the ice will remain fixed, and the water will gradually subside until its normal winter elevation is reached.

It has been stated by Mr Bateman that the sluices through the embankment should be closed during the winter season. This done, the whole volume of the St. Lawrence will have to pass through the South Channel.

From the records kept in the Canal Office of the fluctuation of the water in the harbor of Montreal, and the dates of the shoving of the ice during several years, supplied by the Harbor Master, it has been determined that the winter and spring elevations range from 111 to 117 feet above datum. In the spring of 1869 the river rose to 121.41 feet above datum.

With the view of ascertaining the effect at Laprairie at the time of the shoving of the ice, the whole river passing through the South Channel, Mr. Guerin has prepared a series of calculations, from which it is learned that, at that time, the elevation of the water in the South Channel would become 123.00 ft., and of the river at Laprairie, 123.50 ft., and as the elevation of John Street, Laprairie, opposite Poissant's Hotel is 121.88 ft., it follows that that street would be flooded to a depth of 1.62 ft., or 1 ft. 7½ inches.

These calculations are based on an average rise in the river at the time of the shoving of the ice to 114 ft. above datum, and it may therefore be assumed that, if the embankment be constructed and the sluices kept closed, Laprairie and all surrounding country below the level of 123.50 ft. above datum will be flooded, unless a sufficiently high levee be built to keep the river within bounds.

The question of floods at the time of the shoving of the ice has also to be considered, and the flood of 1869 is taken by Mr. Guerin as an example.

On the 18th April of that year the ice shoved in the harbor,—on the 18th it shoved again, and on the 19th further shoving took place, resulting in the flooding of Griffintown, the flood lasting until the 23rd. From the Canal registers it has been ascertained that on the 15th April the elevation of water in the harbor was 109.75 ft. above datum; on the 18th, 116.95 ft; on the 22nd, 121.41 ft.; and on the 23rd it had fallen 115.25 ft.

From the data thus obtained, it has been computed, that if the proposed embankment had been in existence in April 1869, the sluices all closed, and the river compelled to pass through the South Channel, the elevation of the water would have been 131.43 ft. above datum.

The elevation of the water at Laprairie during this flood was ascertained to be 125.72 ft., or 4.81 ft. higher than at Montreal, and of course the whole place was flooded, and the inference therefore is, if the whole of

the water of the St. Lawrence is passed through the South Channel, and a flood similar to that of 1869 should occur—which is always possible—then the whole of the banks of the river to the foot of the Lachine Rapids must be overflowed, and the damage done would be beyond measure or recompense; and in fact so large would it be, that it would far outweigh all the advantages to be derived by a Company from the construction of the proposed Embankment at Montreal.

It may be stated here that the general elevation of Point St. Charles district is from 121 to 122 ft. above datum, and the elevation of Chaboilles Square in the City is 120 ft., and it may thus be plainly seen that the consequences to Montreal by the construction of this embankment would be most serious.

To sum up. By the construction of the embankment proposed, with the sluices always open, the water in the Harbor of Montreal *might possibly* be maintained at a height 9½ inches below its present normal summer level; that the interference with the navigation would cause a small increase in the length of the trips of the ferry steamer between Montreal and Laprairie, or of those of the steamers which descend the Lachine Rapids; that flooding of both sides of the river to at least Laprairie would be of annual occurrence, with the certainty that during a flood similar to that of 1869, a very large extent of country and of the city of Montreal would be submerged; and in view of these facts it becomes very doubtful whether the possible loss and damage which would be caused if the works proposed be constructed, would not greatly exceed all or any of the advantages claimed by the promoters of the scheme and endorsed by their engineer.

In this matter there are other interests to be looked at than the mere granting of privileges to a company, who propose to obtain from them a sufficient sum to cover working expense and dividends on their outlay. No doubt the creation of further milling and manufacturing power at Montreal, and providing another crossing for railway traffic and highway travel as well across the St. Lawrence, would be of benefit, but if this benefit is to be created by causing damage, discomfort and loss to those who occupy lands on either side of the river above the site of the proposed embankment, and who have rights and privileges which must be respected

and regarded, then it is plainly to be stated that neither authority nor permission should be given to any person or body corporate to construct the works proposed by the St. Lawrence Bridge and Manufacturing Company.

Any interference with so great a river as the St. Lawrence, whereby any of its channels or passages are closed, or its course in any way changed or diverted, should be guarded against with a most jealous hand. Canada has had one experience in interfering with this river at the entrance to the Beauharnois Canal; for what was thought to be a simple matter—the mere closing of a channel, or passage between an island and the mainland, caused a flooding of the lands bordering Lake St. Francis, and to settle the claims for damages sustained involved the expenditure of a very large amount of money, and claims of a similar kind and nature would follow after the construction of the proposed embankment at Montreal, and it becomes questionable whether such claims should be settled and paid by the Company which had constructed the embankment, or the Crown which gave authority for its construction.

It may be remarked that not any reference has been made herein to the probable effects the presence of the proposed embankment in the harbor will have on the Lachine Canal.

It has been shown that with all the sluices closed, the water in the harbor will be reduced 3 feet below low water, summer level, or when there is 17 feet depth on the sill of lock No. 1; and as there would always be a probability that, if open as proposed, the sluices might, from causes beyond control, become, in whole or in part, closed during the season of navigation, a reduction in depth on the sill of lock No. 1 would, as a consequence, follow, and the admission of deep draught vessels become an impossibility; and the benefits and advantages now enjoyed without interruption or interference, advantages obtained at a great expense for the trade and traffic of the Dominion, would be destroyed.

I have the honor to be,

Sir,

Your obedient servant,

HENRY F. PERLEY,

Chief Engineer.

HENRY F. PERLEY, Esq.,

CHIEF ENGINEER OF PUBLIC WORKS.

SIR,

I have the honor to submit the following report in accordance with your instructions directing me to procure the data necessary to ascertain the consequences which will result to existing interests, from the construction of works proposed by "*The Montreal St. Lawrence Bridge and Manufacturing Company*," in the Harbor of Montreal, designed by Mr. T. Foster Bateman, M. I. C. E., who submits plans and description thereof, copies of which I have received.

Data Sought.—In searching for such information as is already known respecting the River opposite Montreal, I have to acknowledge the politeness of the Commissioners and Officers of the Harbor Board in offering to place at my disposal any plan or document in their possession which I might require. I accordingly obtained from their office a section of St. Mary's Current with a plan of the harbor showing its current line and velocities on a given day, which have saved me much labor.

I have to make a similar acknowledgment to the Officers of the Canal Office in Montreal, who have supplied me with the elevations of the water in the harbor for every day throughout the past year, and also a plan of that portion of the River in the vicinity of Moffat's Island.

In order to ascertain the state of the River on any given day, Bench Marks were established on the South shore between Longueuil and Laprairie, and a similar course was pursued on the harbor side from a point below the harbor to the mouth of the St. Pierre River above the Victoria Bridge.

Before the breaking up of the ice, a section was obtained of the channel on the south side of St. Helen's Island last March, and the velocities of the water passing this section were found at the time of high water last summer. You will find these sections, etc., at the end of this report.

Former Reports.—Previous to the introduction of this scheme, various experts were appointed from time to time in years past, to examine the Harbor at Montreal and recommend some plan both for improving the navigation of the River in its vicinity and preventing the floods which are known to occur at certain times. If you have read their reports, you must

have seen that they were invariably based on hypotheses and opinions which had no foundation in fact.

An engineer's opinion is of no more value than that of any other intelligent man. By an "opinion" I mean a statement which he supposes to be correct, but the accuracy of which he is not able to prove nor has he ever known it to have been proven by any one else. Such a statement is worthless and should not be received. The phrases "I believe," "I think," "I am of opinion," &c., appearing in a report are evident acknowledgments that the writer doubts the accuracy of his own statements—You will, therefore, not feel surprised if in the discussion of the subject I am now commencing, I ignore the hypotheses and opinions enunciated by those who have hitherto written on the subject of the Harbor of Montreal. The facts will be simply taken up as they are found to exist, and let Hydraulic science declare the conclusions deducible from these facts.

Periods of High and Low Water.—From the information obtained from the Register in the Canal Office, as well as from observations during the spring and summer of last year, it appears there are three periods of high and low water in the Harbor of Montreal every year.

On the departure of the ice the River falls, arriving at its minimum elevation about the end of April. After this it rises and attains its maximum summer elevation in June. Then it falls until its elevation again becomes a minimum in November. After this the rains during the fall increase its elevation a little until it commences to freeze, then it rises rapidly to its maximum which it attains as soon as the River freezes across. It then falls a little during the winter, arriving at its minimum about the end of February, then on the snow commencing to thaw it rises and attains its maximum at the breaking up of the ice.

Description of River between Laprairie and Longueuil. On the south side of the River and about seven miles above the City of Montreal is situated the village of Laprairie. Here the River is not less than four miles wide. At a distance of about eight miles below this village and on the same side of the River is situated the village of Longueuil, where the width of the River is a little less than one mile. The portion of the River between these two villages includes the Harbor of Montreal, and is contracted and divided into channels by Nun's Island, the piers and abutments of the Victoria Bridge, and those several islands below the latter, the principal of which is St. Helen's Island, the last of the group being Ile Ronde situated below St. Helens.

St. Helen's Island divides the River into two channels, the one on the Harbor side being called "St. Mary's Current," that on the opposite side is called "the South Channel."

The action of the water in these two channels will engross the principal part of the present discussion.

Looking at the map of the River from Laprairie to Longueuil, it can be seen at once that it is not in train in any part of this distance for one hundred feet of its length. No formula for finding the velocity in terms of the inclination is, therefore, applicable to this portion of the River.

Proposed Scheme. — The proposed scheme contemplates turning the St. Lawrence into the south channel by a Dam from Point St. Charles to St. Helen's Island. This Dam is to contain sluices for the two fold purpose of milling service and of regulating the depth of water in the Harbor.

Subjects to be investigated.—In examining what the consequences will be to existing interests when the works contemplated in this scheme shall have been completed, it becomes necessary to examine,

1. How it will affect the depth of water in the Harbor, and
2. How it will affect the land on either side of the River.

Datum of elevations and units of measurement. All elevations of the harbor are referred to the sill of lock No. 1 Lachine Canal and are computed from a datum 81 feet below this sill. It is considered low water in the Harbor when there is a depth of 17 feet on this sill, so that the elevation of the sill is 81 feet, and the elevation of low water is 98 feet above datum.

The units of measurement in the present Report will be *one foot* and *one second*.

In order that the mind may not be interrupted while pursuing the thread of the argument throughout this discussion, all calculations and formulæ are placed in notes at the end, being designated by letters of the alphabet, so that they can be conveniently examined when necessary.

Scheme in operation during the past year.

I propose now to examine what the results of the scheme would be, had the works been completed and in operation during the past year, and with this view, I have the honor to submit to you the section across St Mary's current as well as the plan of the harbor showing the current line, both of which documents have been already mentioned.

You will perceive that the section line cuts the current line at an angle of 50°.30′ and at the point of occourse the velocity is $\frac{5.75 + 5.84}{2}$ miles per hour, or 8.132 feet per second.

From this we find that the mean velocity computed at right angles to the section will be 5.65 feet per second. This was the velocity on the

20th May 1876, when the current line was obtained, and by it we are enabled to obtain the velocity at this place in any given stage of the River.

Discharge of the River St Lawrence. The River St. Lawrence was at its maximum summer elevation on the 6th June last, and on that day there was passing in it 431,733 cubic feet per second — see note A (1) and note B (1) at the end.

The elevation of the river was in the vicinity of its minimum on the 24th Nov. last and on that day it was discharging 281,581 cubic feet per second, see note A (3) and note B (3).

Let any day be assumed between these limits and let us examine what the condition of the harbor would be on that day, should the proposed scheme be in operation. Let the 14th of September last be proposed as the day for this examination, the elevation of the water in the harbour being them 99 feet, or one foot above low water.

Condition of the River on the 14th Sept., works in operation. On referring to note A (2) at end, it will be seen that the discharge through Current St Mary on the 14th Sept. was 270,242 cubic feet per second and the discharge through the South Channel, per note B (2), on the same day was 19,175 cubic feet per second, and when all the river passes through the South Channel, the surface will be raised from an elevation of 99 feet to 108 feet, (see note D). This should be 107.84 but 108 is adopted for brevity. This would be the elevation in the South Channel on 14 Sept. had the proposed Dam been built and all the sluices closed on that day.

In this state of things the only supply to the Harbor is the Lachine Canal, and the water which backs into it from the River below the islands or opposite Longueuil. It is claimed that 85 million cubic feet per hour will pass into the Harbor by the Ile Ronde Channel. This will be noticed presently.

As the difference of elevation betwen the water in the Harbor and that at Longueuil before the works were built was about 2.25 feet. it follows that on the 14th Sept. last, the elevation of the water at Longueuil was 99.00—2.25 or 96.75 feet above datum.

If the River opposite Longueuil were in a quiescent state, then, after the works were built, the Harbor would be supplied from that locality in virtue of the hydrostatic pressure, and the elevation would be the same as at Longueuil or 96.75 feet. But according to Bayfield's chart, the River there has a velocity of 4 knots an hour, and as it is a principle in hydraulics that the lateral pressure of running water is equal to the whole head minus the head due to the velocity, this elevation of 96.75 must be diminished by the head due to 4 knots an hour so as to obtain the actual elevation of the water in the Harbor.

The head due to a velocity of 4 knots an hour is $\frac{7}{10}$ feet; hence the elevation of the water in the Harbor on the 14th Sept., would be 96.75 — 0.70 or 96.05 feet. It is thus reduced 99.00 —96.05 = 2.95 feet, or say *three* feet below the elevation it had before the construction of the works.

It must be borne in mind that the contribution from the Lachine Canal does not assist in lessening this deficiency, as it has already contributed to raise the elevation at Longueuil to 96.75 feet, and it is credited there with its discharge.

To restore this amount of 3 feet, the sluices are opened according to the proposed scheme, and a quantity equal to 850 million cubic feet per hour, or 236,111 cubic feet per second is taken from the South Channel and poured into the harbor. Let us now investigate the result of this operation.

At this stage of the investigation it becomes necessary to bear in mind, that, before the sluices were opened, a quantity equal to 287,129 cubic feet per second, or the whole River was being discharged through the south channel, (see note D), and its elevation had risen from 99 feet to 108 feet above datum: so that at this elevation there is an equality between the discharges of the South Channel and the River St. Lawrence, and it required an accumulation of 9 feet of water over its previous depth in the South Channel before this equality was established.

It follows that during the time this accumulation was taking place there was only a portion of the River passing to Longueuil, for the remaining part went to form the accumulation until the water was raised 9 feet above its previous level: after this the entire River passed on to Longueuil and the equality was restored between the discharges through the South Channel and the River.

While this state of things exists, the water in the harbor being 3 feet below its legitimate level, and 2 feet below the low water level and 12 feet below the level of the water in the South Channel, the sluices are opened, and through them a quantity equal to 236,111 cubic feet per second is passed into the harbor. This will undoubtedly give temporary relief by raising the level of the water in the harbor, but it will be only temporary, for it must not be forgotten that there was at the same time a quantity passing through the South Channel equal to 287,129 cubic feet per second (note D). It follows therefore that 287,129 + 236,111 = 523,240 cubic feet per second is passed from the South Channel by the operation; while the amount supplied to it is only 287,129 cubic feet per second. Hence the accumulation of 9 feet will quickly diminish, and this diminution of head will diminish the discharge through the sluices and the South Channel.

This diminution must continue until an equality is restored, or until the discharge of the St. Lawrence is equal to the sum of the discharges through the South Channel and through the sluices; that is, until the sum

of these two latter discharges is equal to 287,129 cubic feet per second. It is only when this state of things exists, that the level of the south channel or that of the harbor can become permanent. This is the state at which the River must ultimately arrive, and the level of the water in the harbor will then be $\frac{8}{10}$ feet below the level it previously had, as will be seen below.

Elevation of the South Channel and harbor when the discharge of South Channel and sluices on one side equals that of the River on the other side.

By looking at the investigations contained in notes D (2) to D (9) it will be seen note D (4), that when all the sluices are opened and an equilibrium established, as stated in the margin, the elevation of the South Channel will be 103.61. At the same time the elevation of the harbor (note D (9)) will be 98.20.

This elevation 98.20 shews the permanent state of harbor, or the state at which it will arrive after the supply through the sluices, plus the discharge through the South Channel, equals the discharge of the River south of the embankment.

It has been already shewn that in this state of things no further increase can be afforded to the harbor through the sluices, but it is stated in the report submitted with the proposed scheme, that a quantity equal to 85 millions of cubic feet per hour will be supplied to the harbor through the channel between Ile Ronde and St. Helen's Island. I cannot find any data to warrant a conclusion so definite as this—some water will pass through that channel certainly, but how any can be made to pass into the harbor the report accompanying the plans of the scheme does not state. The velocity in the South Channel; the elevation of the surface of this channel above that of St. Mary's Current; the dimensions of the channel between St. Helen's Island and Ile Ronde; the angle this channel makes with St. Mary's Current, as well as the velocity of this current, are all functions of the quantity which would have a tendency to pass through to the harbor.

Until it can be shewn how this quantity of 85 millions of cubic feet per hour can be passed into the harbor, it cannot be allowed to enter into the computations embodied in this report.

The elevation of the harbor before the works were built was	99.00
The elevation after an equilibrium becomes established.....	98.20
Amount by which the harbor is lowered.....	0.80 ft.

This quantity 0.80 feet or 9½ inches is the amount by which the harbor would be lowered in consequence of the existence of the proposed works.

The elevation of the South Channel, and consequently the discharge from the sluices cannot be increased during the period of navigation.

It has been already shown that there is no permanence in the level of either the South Channel or the harbor until the discharge of the St. Lawrence is equal to the sum of the discharges through the South Channel and the sluices. It appears evident from this, that if we want to raise the level of the water in the South Channel, we must make the discharges from the sluices and through the South Channel taken together, less than the supply from the St. Lawrence : but if we do this, we lower the level of the water at Longueuil and lower accordingly the level of the water backed therefrom into the harbor. Let us assume an example which is likely to occur.

Suppose the South Channel is reduced three feet, and that we want to regain this head. To do this we close the sluices that the water may accumulate. The elevation in the South Channel having been reduced by 3 feet stands at 104.84 above datum, (see note D (1)), and its mean depth becomes 7.59 ft. The quantity of water passing through it at this depth will be 174,[illegible]7 cubic feet per second, (see note E). This quantity increased by the discharge from the Lachine Canal will give 177,255 cubic feet per second passing to Longueuil, on having closed the sluices.

I have now the honor to submit a section of the River at Longueuil, taken from Bayfield's Chart, where it will be seen that the mean depth when it is low water in the harbor is 19.35 feet, the river being then discharging 277,248 cubic feet per second, (see note B (3)).

From these data we find, (see note E) that the mean depth at Longueuil will be reduced to 14.34 ft., or in other words, the level of the water at Longueuil is reduced 5 feet below its level at low water on shutting off the sluices, and as the level which affects the harbor there was originally 3 feet below that of the harbor, or at an elevation of 96.00 ft., it follows that the level of the harbor would be reduced to an elevation of 96.00—5.00=91.00 ft. above datum.

This shows that the level of the water in the harbor would be reduced 7 ft. below low water by the operation—of course 91 feet is the minimum and this level must be of very short duration, as the water will commence to rise immediately on the discharge increasing through the South Channel, or as the water accumulates and the mean depth increases in that channel.

Conclusion of discussion on sluices.

The conclusion to be drawn from what has been discussed up to this point in the present report is this.—The sluices, once being opened and permitted to run for any time cannot be closed again without lowering the level of the water in the Harbor below the level of low water.

CONDITION OF THE RIVER IN WINTER.

In discussing every project for Harbor improvements at Montreal, the ice becomes a function of the investigation. It is well known that before the River becomes frozen across, it first commences to rise and continues to do so until the ice bridge is formed : yet this rising takes place notwithstanding that there is no visible cause to warrant the supposition that the quantity of water in the River is increasing, for no rain or snow had fallen to cause such an increase. It rises because the wetted perimeter is increasing by the ice bordages, as will be seen presently.

Immediately after the River has frozen across it rises suddenly. It then subsides to a constant level for a short time, after which it gets lower as has been already described. At the approach of spring it rises and breaks up the ice, and this rising is generally greater than that which took place in the previous winter. All these phenomena occur in accordance with the laws established by Hydraulic science as will be shewn further on.

The several experts who have been at times commissioned to report on improving this Harbor, have referred to these phenomena, and in opposition to the first principles of Hydraulic science they impute the cause to " Ice Dams " and " Ice Jams " formed in St. Mary's Current, quoting from a paper read by Sir Wm. Logan on the subject of geology forty years ago before the Geological Society of London, in which he alludes to the winter phenomena in the St. Lawrence.

I wish it to be understood that I disavow any intention of stating anything here which may have a tendency to lessen the prestige attached to the memor of Sir Wm. Logan. No: I had the pleasure of his acquaintance and enjoyed his friendship for several years in the latter part of his life. He had no greater admirer of his abilities than I was, nor has any one a greater respect for his memory than I have.

Hydraulic science was not developed then as it is now, and Sir Wm. Logan was too much engrossed in the developement of his favorite science Geology, to devote much attention to Hydraulics.

In consequence of this, on witnessing the shoving of the ice in St. Mary's Current, he did not understand the law that governed the forces which produced the phenomena that were taking place in his presence ; but, being determined to find an explanation, he framed an hypothesis by imagining that the great quantity of ice coming down the river becomes packed at the foot of the Current St. Mary and forms a dam extending in some places to the bottom. Hence the rise of water. Hence the floods, etc :—

In every report on the improvement of the Harbor of Montreal, this hypothesis is adopted, and it is now generally believed that the River rises

in winter in the Harbor of Montreal in consequence of the floating ice becoming jammed and forming a Dam across St. Mary's Current. Now the specific gravity of ice is about $\frac{9}{10}$ that of water, so that a piece of ice in the river will have $\frac{9}{10}$ of its volume below and $\frac{1}{10}$ above the surface of the water. It would therefore be as competent for that piece of ice to rise in the air as to sink deeper in the water. There are only too ways for floating ice to get aground. One is, when in moving forward the submerged portion meets with a shoal or reef. The other is, when being stationary the water subsides from under it. It is impossible that ice can sink deeper than its specific gravity will permit. The current may force a moving piece under stationary ice when its sumerged part projects below that of the stationary, but the whole will be proportionally lifted up.

CAUSE OF HIGH WATER IN WINTER.

It is not an abnormal state of things that the River St. Lawrence should rise when frozen across. There never has been a river, nor stream, nor rivulet that did not rise above its previous level on being frozen across. Hydraulic science not only demonstrates that such a rise must take place, but it enables us to ascertain the height to which the rise will ascend. Here are the facts.

It is a well known principle in hydraulics, that in the same stream, the velocity varies inversely as the square root of the wetted perimeter, and it is shewn in notes A and B that the wetted perimeters of St. Mary's Current and the South Channel, are for all practical purposes equal to the width of the streams in each case where the section was taken. Hence it follows that the moment the River is frozen across, the wetted perimeter is twice what it was in open water, and the ratio of the velocities in both cases will be as $1 : \sqrt{\frac{1}{2}}$, or as $1 : 0.70$; or in other words, the velocity after being frozen across will be $\frac{7}{10}$ the previous velocity.

Before the ice was formed on the River the maximum velocity was on the surface and in the centre of the stream—after being frozen across, the River assumes the character of a tube, and the fillet of maximum velocity is transferred from the surface to the middle of the depth as in a pipe, provided the under surface of the ice and the bottom of the River are of the same degree of roughness or smoothness. Should the under surface of the ice be rougher than the bottom of the River, the fillet of maximum velocity will be found nearer the bottom and its velocity will be less and *vice versa*. It follows then that the winter velocity of a stream will depend on the roughness or smoothness of the under surface of the ice, and if this roughness is greater than that of the bottom of the River, the velocity of the stream will be less than $\frac{7}{10}$ its previous velocity, and if smoother the co-efficient will be greater.

To form some idea of the state of the under surface of the ice, let us suppose three cubes of ice floating adjacent to one another, one of which projects four inches above the surface of the water, another two inches and the third one inch. Then the depths below the surface of the water to which these pieces will respectively extend will be 36″, 18″, 9″; that is to say, the under surface is *nine* times as rough as the upper surface. From this example we can form some idea of the roughness of the under surface of the ice in the Harbor of Montreal; and we may reasonably expect that the co-efficient of velocity will be less than $\frac{7}{10}$; but fortunately for our present inquiry we have the means at hand of ascertaining this co-efficient accurately. Here it is.

Co-efficient of velocity for winter. I now call your attention to a plan herewith submitted, of that portion of the River in the vicinity of Moffat's Island, kindly furnished me by Mr. Harrington, of the Canal Office, under whose direction the survey was made a few years ago. It can be there seen that although the summer velocity of the River in this locality was 7 miles an hour, yet the winter velocity was only $3\frac{1}{2}$ miles per hour. This shows that the co-efficient of velocity in Montreal Harbor is not $\frac{7}{10}$ but $\frac{5}{10}$. Mr. Harrington has furnished me with the measurements that were made at the time of the survey, and the average would give a co-efficient somewhat less than $\frac{5}{10}$: but I shall adopt the co-efficient as stated on the plan.

Mean Depth doubled in winter, From the foregoing it can be easily shewn that the mean depth of the harbor is doubled in winter—thus;

Let Q = Discharge of the River in feet per second.
W = width.
v = velocity in feet per second.
H = mean depth.
Then we get

$$Q = W.\ H.\ v \text{ and } \frac{Q}{W} = H.\ v.$$

Here Q and W are both constant quantities, for neither the discharge nor the distance between the River Banks is affected by the frost. It follows that the product H. v is constant, so that if v is diminished H, must be increased in the same ratio. Then if v becomes $\frac{1}{2}\ v$; H must become 2 H.

Now if v denotes the velocity of the current before being frozen across and H. the mean depth at that time, these quantities in winter must become $\frac{1}{2}\ v$ and 2 H. or in other words the mean depth of the River in the

Harbor of Montreal while free of ice will be doubled when the River is frozen across.

Height to which River will rise in winter. We have now the means of ascertaining the height to which the River will rise on being frozen across in any year. Here are the facts for the present winter.

On the 24th Nov. last immediately before any ice was formed. (See notes A (3), B, (3)

	Sq. ft.
The sectional area of Current St. Mary was.....	54,865
Do South Channel.....	4,685
Entire sectional area of both channels	59,550
Water line of Current St. Mary at section.....	2,250 ft.
Do at South Channel.....	2,625 "
Entire width of water surface.....	4,875 ft.

$$\text{Mean Depth} = \frac{56{,}550}{4{,}875} = 12.22 \text{ feet.}$$

Elevation at Section St. Mary's Current....	97.25	mean
Do South Channel.....	98.75	98.00
Elevation at Lock Sill.....	98.50	

Hence 98.00 + 12.22= 110.22. This will be the elevation of the water in the Harbor after the ice has ceased to shove.

The present passage of this report is written on the 21st Dec. and before the River has yet been frozen across; it can therefore be easily ascertained whether these figures will become verified.

Shoving of Ice.—It has just been shown that on being frozen across the river must rise in the Harbor to a height equal to its mean depth above its previous level. When it settles at this elevation it is in its normal state: but during the shoving of the ice the state of the river is abnormal. It is by the shoving and lifting of the ice that it arrives at its normal state.

Explanation.

Let us suppose that it becomes frozen in the channels on each side of St Helen's Island while it is yet open water at Victoria Bridge, and above this Bridge: a circumstance which generally occurs before the River is frozen permanently. Then the stream under the ice moves only with half its previous velocity, while the open water above preserves its entire velocity. It follows, that the open water must accumulate on reaching the slower current which is covered with the ice, it will therefore lift up the

ice, and continue to do so until its mean depth is doubled. At first the water must rise higher than the mean depth and for the following reason.

Whereas it will be in its normal state only when its mean depth is doubled, the mean depth of the whole Current St. Mary and the South Channel must be doubled before this state shall have been arrived at. The open water in front of the ice increasing faster than the ice is being lifted, the ice will become broken and shoved by the increasing flood until the whole body is lifted to the required height: then the water in front having space enough to pass through, the abnormal accumulation will subside. It is manifest then that the river will rise higher during the shoving of the ice than at any period during the winter.

WINTER STATE OF RIVER WHEN ALL THE WATER PASSES THROUGH THE SOUTH CHANNEL.

I have now to call your attention to the record of the elevations of the harbor kept at the Canal Office, and I have furthermore to submit a report supplied to me by the Harbor Master of Montreal showing the dates of shoving of the ice for several years past.

Comparing these documents it can be seen that at the time the ice shoves, the River rises to its maximum winter and spring elevations. These elevations vary from 111 to 117 feet above datum. In the spring of the year 1869 the elevation was 121.41 feet.

Let us adopt 114 feet as the general maximum elevation in ordinary years during the shoving of the ice, and let us compute the elevation in the South Channel should it then be compelled to discharge the entire River. See notes F (1), (2), (3), (4).

The elevation in South Channel is found to be 123.00. Note F (3).

The elevation at Laprairie is found to be 123.50. Note F (4).

The general elevation of John street Laprairie opposite Poissant's hotel is 121.88.

This street would therefore be submerged during the shoving of the ice every year after the works shall have been completed and the sluices closed.

FLOODS.

When a flood takes place in the City of Montreal or Laprairie, the cause is imputed to "Ice Jams" and "Ice Dams" supposed to have been formed on each side of St. Helen's Island.

I have no data respecting any of these floods but that of the year 1869 which is given in the Harbor Master's report already mentioned.

It will be seen in that report, that on the 13th April 1869 the ice

shoved in Montreal Harbor. On the 18th it shoved again and on the 19th it shoved flooding Griffintown, continuing until the 23rd.

On referring to the register kept at the Canal Office it will be seen that on the 15th April 1869 the elevation of the water in the harbor was 109.75 feet above datum, on the 18th it was 116.75 ; on the 22nd it was 121.41 and on the 23rd it was 115.25 feet above datum.

The levels which were taken to Laprairie last year showed that the elevation there of the flood of 1869 was 125.72 feet above datum—the inhabitants pointing out by a certain mark the height to which that flood had risen.

Now, it is shown in note F (4) that an elevation of 123.00 in the harbor would raise the Hydraulic Amplitude at Laprairie to an elevation of 123.50 ; consequently an elevation of 121.41 in the harbor would cause an elevation at Laprairie less than 123.50 and much less than 125.72. It follows therefore that the flooding of Laprairie in 1869 could not have been caused by the raising of the water in Montreal Harbor, but it must have been caused by the surcharging of the River on account of some unusual quantity of water poured into it from some other source. This is the conclusion to which Hydraulic Science leads us.

I am aware that this conclusion is at variance with the generally received opinion. I am also aware that there are many who despise the deductions of science if they conflict with their own previously conceived hobbies.

In view of all this being the case I felt anxious to prosecute the enquiry farther, although I had no doubt as to the result. Accordingly the Rain and Snow Registers kept by the Department of the Montreal Water Works and McGill College were referred to, and from an examination of these it appears, that although the snow gauge generally registers a depth of snow during each winter varying from six to nine feet, yet in the winter of 1868-9 the register showed an amount of fourteen feet, and of this amount 6½ feet was registered for the single month of February.

This great depth of snow spread over the water shed of the St. Lawrence, having been thawed in the spring and conveyed to the River by its tributaries, it thus became surcharged and in consequence it flooded the country. The flood therefore arose from the fact that the River was surcharged by the quantity of water poured into it by its own tributaries and not from any imaginary "Ice Jams" or "Ice Dams" in the vicinity of Montreal. This conclusion is further verified by the Register in the Canal Office which shows that during the entire summer of 1869 the water in the Harbor of Montreal was unusually high, or in other words, the quantity of water produced by the snow of the previous winter was com-

petent to raise the level of the river during the whole of the succeeding summer.

Consequences of Flood of 1869, *if proposed works were then in existence.* } Let us now inquire into the consequences which would result, had the proposed scheme been in existence during the flood of 1869.

On referring to Note G (3), it will be seen that if the proposed scheme were in existence at that time, and all the water of the River were made to pass through the South Channel, Levees being built confining that channel to a width of 3,000 feet, the elevation of the water in it on the 22nd April 1869 would be raised to 131.43 feet above datum.

The elevation of the Railway Track approaching the Victoria Bridge, Point St. Charles as obtained at the City Surveyor's Office Montreal is 122.55 ft.

The general elevation of Point St. Charles is from 121 to 122 ft.

Point St. Charles District is drained into the sewers of the City proper.

The elevation of Chaboillez Square in the City is 120.00 feet.

With these levels the consequences to the city would be serious, and considering these facts, it becomes at once evident that the sluices should not be closed during winter. They should be open, giving as much freedom as possible at such a season of the year to the flow from the South Channel.

Respectfully submitted,

THOS. GUERIN,
Eng. Dep. Pub. Works.

Dep. Pub. Works,
Ottawa, March 12th, 1883.

NOTE A (1)

CURRENT ST. MARY ON 6TH JUNE, 1882.

SEE SECTION.

Elevation of water at section on 6th June	102.91 ft.
Length of section on surface on 6th June	2287.50 "
Do when level with 17 ft. on sill	2262.50 "
	sq. ft.
Area of section on 6th June	67,948.38
Wetted perimeter do	2316.39 ft.
Hydraulic depth do	29.33 "
Mean depth do	29.70 "
Hydraulic depth time of current line	33.22 "

At the time current line was obtained.

velocity at section $\frac{5.75 + 5.34}{2}$	= 5.54 miles p. hour.
Mean velocity perpendicular to section	5.65 ft. p. second.
Velocity on 6th June	5.31 ft. p. second.
Discharge June 6th, Q =	360,805 cub. ft. p. sec.

NOTE A (2)

CURRENT ST. MARY ON 14TH SEPT. 1882.

SEE SECTION.

Elevation of water at sill of lock	99.00 ft.
Do at section	97.53 "
Water line or length of section, 14th Sept	2250.00 "
	sq. ft.
Area of section on 14th Sept	55720
Wetted perimeter do	2275.47 ft
Hydraulic depth do	24.47 "
Mean depth do	24.76 "
Hydraulic depth time of current line	33.22 "

Velocity perpendicular to section at time of current line.. 5.65 ft. p. sec.
Velocity perpendicular to section on 14th Sept..... 4.85 "

Discharge on 14th Sept. Q = 270242 cubic feet p. second.

NOTE A (3)

CURRENT ST. MARY ON 24TH NOV., 1882.

SEE SECTION.

Elevation of water at sill of lock	98.50 ft.
do at section	97.15 "
Water line of section, Nov. 24th	2250.00 "
	sq. ft.
Area of section, do	54865.63
Wetted perimeter, do	2271.31 ft.
Hydraulic depth, Nov. 24	24.25 "
do time of current line	33.22 "
Mean depth, Nov. 24th	24.48 "
Velocity perpendicular to section; time of current line	5.65 p. sec.
Velocity perpendicular to section on 24th Nov	4.82 "

Discharge on Nov. 24, Q = 264452 cubic feet per second.

NOTE.—On the 30th Nov., elevation at sill was..... 98.00 ft.
or low water.

At that date, Nov. 30th, the elevation at section was..... 96.85 ft.

Hence, discharge at low water, Q = 260,114 cubic feet per second.

NOTE B (1)

SOUTH CHANNEL ON 6TH JUNE, 1882.

SEE SECTION.

Elevation at sill on 6th June	104.50 ft.
do at section across South Channel	103 23 "
	sq. ft.
Area of part A B C of section	9070
Length of water line	1175.00 ft.
Wetted perimeter	1176.00 "
Mean velocity	5.52 ft. p. sec.
Mean and hydraulic depth	7.72 ft.
	cub. ft.
Discharge through part A B C, June 6th, 1882	50066.00 ft.
	sq. ft.
Area of C E F	7001.00
Length water line	1487.00 ft.
Mean velocity on 6th June	2.98 ft. p. sec.
Mean depth	4.70 ft.
	cub. ft.
Discharge through part C E F	20862.00
	cub. ft.
Entire discharge	20862 + 50066 = 70928.00
	sq. ft.
Entire area of section	16071.00
Entire width of water way	2662.00 ft.
Mean depth of entire section	6.037 "

Entire discharge of St. Lawrence on 6th June, 1882:

Current St. Mary, p. Note A	360805 cub. ft.
South Channel	70928 "
Q =	431733 " p. sec.

NOTE B (2)

SOUTH CHANNEL ON 14TH SEPT., 1882.

SEE SECTION.

Elevation at sill on 14th Sept	99.00 ft.
do at section South Channel	99.00 "
	sq. ft.
Area of part A′ B′ C′ of section	4374.00 "
Length of water line	1002.00 "
Wetted perimeter	1003.00 "
Hydraulic depth	4.36 ft.
Mean depth	4.37 "
Mean velocity through A′ B′ C′	4.15 ft. p. sec.
	cub. ft.
Discharge through A′ B′ C′	18152.00
	sq. ft.
Area of part C′ E′ F′	853.00
Length of water line	1100.00 ft.
Wetted perimeter	1100.00 "
Hydraulic depth	0.77 "
Mean depth	0.77 "
Velocity	1.20 ft. p. sec.
Discharge Q =	1023.00 cub. ft. p. sec.
Entire discharge through South Channel on Sept. 14th	19175 cub. ft.
Discharge through Current St. Mary, p. Note A (2)	270242 "
Entire discharge of river on 14th Sept.	289417 "

NOTE.—Mean depth for entire section 1.96 ft.
Mean depth at 3000 ft. width 1.74 "

NOTE B (3)

SOUTH CHANNEL ON NOV. 24TH 1882.

ONE SECTION

Elevation of water at sill Nov. 24th.....	98.50 ft.
do at section line.....	98.75 "
On Nov. 30th (Low water) Elevation the same.....	98.75 "

ERRATA.

Page 9, 26 lines from top, for $\sqrt{2}$ read $\sqrt{\frac{1}{2}}$.

Page 35, 16 lines from top, for $Q^1 + q^1 - Q$ read $Q^1 + q^1 = Q$.

Page 35, 2 lines from bottom, for $H^{1\frac{1}{2}}$ read $H^{1\frac{1}{2}}$.

Page 47, 2 lines from top, for 123.00 read 123.02.

Page 47, 11 lines from top, for $(9.355)^6$ read $(9.85)^6$

On the 30th the elevation at sill was 98.00 or low water.
The discharge at low water will be as follows.

	Cub. ft.
St. Mary's Current per note A (3).....	260,114
South Channel its level being the same as on the 24th...	17,129
Total.....	277,243 cub. ft.

The discharge of the St. Lawrence at low water at Montreal is 277,243 cub. feet per second.

NOTE B (2)

SOUTH CHANNEL ON 14TH SEPT., 1882.

NOTE.—Mean depth for entire section	1.96 ft.
Mean depth at 3000 ft. width.....	1.74 "

NOTE B (3)

SOUTH CHANNEL ON NOV. 24TH 1882.

SEE SECTION

Elevation of water at sill Nov. 24th		98.50 ft.
do at section line		98.75 "
On Nov. 30th (Low water) Elevation the same		98.75 "
	Sq. ft.	
Area of part A′ B′ C′	4124.00	
Length of water line	1000.00 ft.	
Wetted perimeter	1001.00 "	
Mean Depth	4.12 "	
Hydraulic Depth	4.12 "	
Mean velocity	4.03 ft. p. sec.	
Discharge through A′ B′ C′	16619 cub. ft. "	
	Sq. ft.	
Area of portion C′ E F′	561.00	
Length of water line	1100.00 ft.	
Wetted perimeter	1100.00 "	
Mean Depth	0.51 "	
Hydraulic Depth	0.51 "	
Mean velocity	0.91 ft. p. sec.	
Discharge through C′ E F′	510.00 cub. ft. p. sec.	
Entire discharge through South Channel	17129 " "	
Discharge through Current St. Mary per note A (3) on Nov. 24th	264452 " "	
Discharge of River on Nov. 24th	281581 " "	
	Sq. ft.	
Area of entire section South Channel	4124 + 561 =	4685
Mean depth with channel widened to	3000 ft. =	1.56 ft.
Mean depth, the width of channel being	2662 " =	1.76 "

SOUTH CHANNEL ON NOV. 30TH, 1882.

SEE SECTION

On Nov. 24th the elevation at sill was 98.50. It was not yet low water.

On the 30th the elevation at sill was 98.00 or low water.

The discharge at low water will be as follows.

	Cub. ft.
St. Mary's Current per note A (3)	260,114
South Channel its level being the same as on the 24th	17,129
Total	277,243 cub. ft.

The discharge of the St. Lawrence at low water at Montreal is 277,243 cub. feet per second.

NOTE D (1)

CONDITION OF RIVER ON 14TH SEPT. 1882 CURRENT ST. MARY TURNED INTO SOUTH CHANNEL.

Elevation on sill Sept 14th	99.00 ft.	
	Cub. ft.	
Discharge of Current St. Mary, Note B (2).....	270,242	
do Lachine Canal.....	2,288	
Quantity supplied Harbor from River.....	= 267,954	cub. ft. p. sec.
Quantity passing through South Cannel B (2)..	19,175	" "
Total discharge through South Channel when works shall have been built.....	287.129	

cubic feet per second.

Mean Depth of South Channel on 14th Sept. note B (2).. ..... 1.74 ft.

Hence we get $H = 1.74 \left(\frac{287129}{19175}\right)^{\frac{2}{3}}$ ..... = 10.58 "

Wherefore elevation of South Channel will be 99 + 10.58 — 1.74 = 107.84 ft.

Accumulation of water in South Channel is 104.84 — 99.00 = 8.84 ft. or say 9 feet.

NOTE D (2).

WHAT WILL BE THE DEPTH IN SOUTH CHANNEL, OR HEAD ON SLUICES, WHEN THE DISCHARGES THROUGH BOTH PLACES ARE TOGETHER EQUAL TO THAT OF THE ST. LAWRENCE MINUS LACHINE CANAL.

General Formula :

Let Q = Discharge of St. Lawrence minus Lachine Canal.

H = Mean depth in South Channel at the instant sluices are opened or before the depth begins to diminish.

q = Discharge through sluices before the head on these begins to diminish.

h = Head on sluices at the same time, or before H or h begins to diminish.

Q′ = Discharge through South Channel when there is an equilibrium between the discharges of the River on one side and South Channel and sluices on the other side.

q' = Discharge through the sluices at the same time or when $Q' + q' = Q$.

H′ = Mean depth in South Channel at such time.

h' = Head on sluices at the same time. Hence H—H′ or h—h' will represent the amount the South Channel has fallen.

Wherefore $H - H' = h - h'$ and $h' = h + H' - H$

Again. $Q : Q' :: H^{\frac{3}{2}} : H'^{\frac{3}{2}}$: and $Q' = Q \times \frac{H'^{\frac{3}{2}}}{H^{\frac{3}{2}}}$

$$q : q' :: h^{\frac{1}{2}} : h'^{\frac{1}{2}} \text{ and } q' = q \times \frac{h'^{\frac{1}{2}}}{h^{\frac{1}{2}}}$$

$$Q' + q' = Q \times \frac{H'^{\frac{3}{2}}}{H^{\frac{3}{2}}} + q \times \frac{h'^{\frac{1}{2}}}{h^{\frac{1}{2}}} = Q \text{ Substitute value of } h'$$

and we get $H^{\frac{3}{2}} = H'^{\frac{3}{2}} + \frac{q\,H^{\frac{3}{2}}}{Q\,h^{\frac{1}{2}}}(h + H' - H)^{\frac{1}{2}}$ whence H′ can be found.

NOTE D (3)

MEAN DEPTH OF SOUTH CHANNEL SEPT. 14TH 1882. SLUICES BEING OPENED AND EQUILIBRIUM ESTABLISHED.

Total discharge through South Channel note D (1)	287,129	cub. ft.	p. sec
Discharge through Current St. Mary.....	270,242	"	"
do Lachine Canal.....	2,288	"	"
do South Channel before receiving Current St. Mary.....	19,175	"	"

Mean depth South Channel, Note D (1).....	10.58 ft.
Elevation of do Sept. 14, Note D (1).....	107.84 "
Elevation of Top of controlling sluice p. Bateman's section.	103.00 "
do Bottom do do do	98 00 "
do Centre do do do	100.50 "

Head on centre controlling sluice 107.84 — 100.50 = 7.34 N.
Hence Q = 287,129 p. note D (1).
q = 236,111 p. Bateman's Report.
H = 10.58 p. note D (1).
h = 7.34 from above.

Substitute these values in general equation Note D (2)

$$(10.58)^{\frac{3}{2}} = H'^{\frac{3}{2}} \times \frac{236111}{287129} \times \frac{(10.58)^{\frac{3}{2}}}{(7.34)^{\frac{3}{2}}} (7.34 \times H' - 10.58)^{\frac{3}{2}}$$

The resolution of this equation with give H′ = 6.35 feet.

NOTE D (4)

HEAD ON SLUICES ALL BEING OPENED.

Discharges through South Channel, sluices all being opened, and equilibrium established.

Hence

$Q' = Q \times \left(\frac{H'}{H}\right)^{\frac{1}{2}} = 133515$ cub. ft. p. second.

$q' = Q - Q' = 153614$ " "

Mean depth of South Channel sluices closed.....10.58 ft.
do do sluices opened ..... 6.35 "

Fall when equilibrium is established..... 4.23 "

Elevation of South Channel, sluices opened.

Elevation of South Channel, sluices opened, and the equilibrium established:
107.84 — 4.23 = 103.61 ft.

Head on sluices when equilibrium is established.

Height or Head on centre controlling sluice will be 103.61 — 100.50 = 3.11 ft.

NOTE D (5)

ELEVATION OF WATER IN HARBOR ON 14TH SEPT., 1882. ALL SLUICES OPENED AND EQUILIBRIUM ESTABLISHED.

Elevation of surface, section Colborne Avenue, above that at Longueuil.

The discharge through the sluices all being opened, and an equilibrium established between the discharge of the St. Lawrence on one side, and the discharges through the South Channel and the sluices on the other side is per last note..... q' = 153,614 cub. ft. per sec.
Lachine Canal..... = 2,288 do

Entire discharge through Current St. Mary = 155,902 do

	Cub. ft.
When discharge through Current St. Mary note B (2)..... =	270242
The elevation at section note A (2)	97.53 ft.
Elevation at Longueuil..... 99.00 — 2.25 =	96.75 "
Height of water of section above that of Longueuil..... =	0.78 "

The elevation at Longueuil is practically the same as at Colborne Avenue or at Section when sluices are closed.

When sluices are opened and Current St. Mary discharges 155,902 cub. ft. per second, the elevations at the section at Colborne Avenue above that at Longueuil will be increased approximately as follows.

NOTE D (6)

ELEVATION OF WATER IN HARBOR ON 14TH SEPT., 1882. ALL SLUICES OPENED AND EQUILIBRIUM ESTABLISHED.

Elevation of section, Colborne Avenue, over that of Longueuil.

Let L = Distance between sections at Colborne Avenue and Longueuil.

Q = Discharge through St. Mary's Current on 14th Sept..... = 270242 cub. ft. per sec.

q = Per note D (5)..... 155902 do

a = Area of Section, Colborne Avenue, 14th Sept = 55720 sq. ft.

b = do Longueuil do = 94769 do

From above we have :

$$Q : q :: \left(\frac{0.78}{L}\right)^{\frac{1}{2}} \times b : \left(\frac{z}{L}\right)^{\frac{1}{2}} \times a$$ Whence

$z = 0.75$ which is the elevation of water of section at Col. Ave. above that at Longueuil.

Elevation at Colborne Avenue.

Wherefore $96.75 + 0.75 = 97.50$ = The elevation at Col. Ave. during the discharge of q or 155902 cub. ft. per second.

NOTE D (7)

ELEVATION OF WATER IN HARBOR ON 14TH SEPT, 1882. ALL SLUICES OPENED AND EQUILIBRIUM ESTABLISHED.

Velocity at Colborne Avenue.

Area of section at Col. Ave. before works were built. Note A (2) 55720 ft. sq.
Width of surface ..... 2250 ft.

Lowering of surface during discharge of 155902 cub. ft. p. second.
Note A (2)..... 97.53 — 97.50 = .03 ft.

Hence area of section at that time will be $55720 - 2250 \times .03 = 55653$. And we get $v. = \frac{155902}{55653} = 2.80$ ft. p. second.

The difference of level between surface of water section at Col. Ave. and that of still water in Victoria Basin = 1.32 ft: but this must be increased by the head due to the velocity of the current outside the Basin, in order to obtain the difference of level between the surface of the water at section and that of the water of the Harbor.

The head due to the velocity outside the Basin is thus obtained.

On examining the current line, it will be seen that the velocity opposite Victoria pier may without sensible error be considered equal to that at the section line at Col. Ave.

The velocity opposite Victoria pier at the time the current line was obtained amounted to $\frac{5.74 + 5.80}{2} = 5.77$ miles per hour = 8.46 ft. p. second.

NOTE D (8)

ELEVATION OF WATER IN HARBOR ON THE 14th SEPT.

ALL SLUICES OPENED.

Inclination of Cur. St. Mary before works are built.

The hydraulic depth at section Col. Ave. = 33.22 ft.

Do on 14th Sept. 1882. Note A (2) = 24.48 ft.

Hence the velocity at section or at Victoria pier on Sept. 14th, will be found as follows:

$\sqrt{33.22} : \sqrt{24.48} :: 8.46 : x = 7.25$ ft.

The height due to this velocity is $\frac{8}{10}$ feet.

Hence the difference of level between the surface of water opposite Victoria pier, and that at section Colborne Avenue = 1.32 + 0.80 = 2.12 feet on 14th Sept. 1882.

Inclination of Cur. St. Mary after works are built.

Now supposing current St. Mary to be in train between Victoria Pier and Colborne Avenue after the works were built, let us find what the inclination will be, so as to discharge an amount of water equal to 155902 cubic feet p. second.

The velocity at sec. note A (2) on 14th Sept. was ..... 4.85 ft.
Difference of level between surface of water at section and that opposite Victoria pier is..... 2.12
The velocity at same place during discharge of 155,902 cub. ft. per sec. was per last note..... 2.80

Hence $(4.85)^2 : (2.80)^2 :: 2.12 : x = 0.70$ ft.

This quantity 0.70 is the difference of level between the surfaces of the water at Colborne Avenue and opposite Victoria pier while the discharge is 155902 cub. ft. p. sec.

NOTE D (9)

ELEVATION OF WATER IN HARBOR ON 14TH SEPT.

ALL SLUICES OPENED.

Permanent level of Harbor.

Hence 97.50 p. Note D (6), + 0.70 = 98.20.

This elevation 98.20 shows the permanent state of the harbor, or the state at which it will arrive after the supply through the sluices, plus the discharge through the south channel equals the discharge of the river minus the Lachine canal. It has been already shown that in this state of things no further increase can be afforded to the harbor through the sluices.

It has been stated, in the report submitted with the scheme, that a quantity equal to 85 millions cubic feet per hour will be supplied to the harbor through the channel between Ile Ronde and St. Helen's Island, but as it has not been shown how this can be effected, no notice can be taken of it here.

NOTE. E.

CONDITION OF SOUTH CHANNEL AND RIVER AT LONGUEUIL, ON 14th SEPT., 1882, WHEN LEVEL OF SOUTH CHANNEL IS LOWERED 3 FEET, AND SLUICES SHUT OFF.

(See section at Longueuil.)

	ft.
Elevation at first per Note D	107.84
do reduced by 3 ft	104.84
Mean depth at first	10.58
do reduced	7.58
	cub. ft.
Discharge at first per Note D	287129

Then we get

$$(10.58)^{\frac{3}{2}} : (7.58)^{\frac{3}{2}} :: 287129 : 174967$$

This is the discharge through South Channel when its level is lowered by 3 ft.

Add Lachine canal = 2288 cub. ft., and we get total passing to Longueuil on 14th Sept., when sluices are shut, and channel lowered 3 feet = 177255 cub. ft. p. sec.

Mean depth at low water, Longueuil 19.35 ft.

Discharge at Low water per Note B (3) 277243 cub. ft. p. sec.

$$\text{Hence } (277243)^{\frac{3}{2}} : (177255)^{\frac{3}{2}} :: 19.35 : 14.34$$

Hence mean depth opposite Longueuil on 14th Sept., when South Channel is reduced 3 ft., and sluices shut off will be 14.34 feet.

NOTE F (1)

CONDITION OF BOTH CHANNELS WHILE ICE IS SHOVING IN ORDINARY WINTERS — THE ELEVATION BEING AT ITS MAXIMUM OR 114 FEET ABOVE DATUM.

Current St. Mary—see section.

	Sqr. ft.
Area of section, elevation being 114 ft.	92253.90
Wetted perimeter do	2549.10 ft.
Length of water line	2527.50 "
Hydraulic depth	36.19 "
Mean depth	36.50 "

South channel.

	Sqr. ft.
Area of section	46064.00
Wetted perimeter	2901.02 ft.
Length of water line	2900.00 "
Hydraulic and mean depth	15.87 "

NOTE F (2)

DISCHARGES THROUGH BOTH CHANNELS WHILE ICE IS SHOVING OR ELEVATION A MAXIMUM.

Current of St. Mary.

Admitting the River to be open when elevation is a max : or as high as it will be while ice is shoving, then we get

$$\sqrt{29.33} : \sqrt{36.19} :: 5.65 : x = 6.24 = \text{velocity.}$$

But being covered with ice this velocity becomes $\frac{6.24}{2} = 3.12$

Discharge (Note F 1) $= 92253 \times 3.12 = 287829$ cub. ft.

South Channel.

Nov. 24th.	Sectional area, Note B (3)		sq. ft. 4685
do	Discharge		cub. ft. 17129
	Mean vel $\frac{17129}{4685}$	=	3.65 ft

Admitting as above that this channel was open when elevation is a max: or as high as it would be while ice was shoving, then we should have

$$\sqrt{1.76} : \sqrt{15.87} :: 3.65 : x = 10.95 = \text{velocity.}$$

But being covered with ice this velocity becomes $\frac{10.95}{2} = 5.47$ ft. per sec.

The discharge at maximum elevation with therefore be note F (1) 46064 $5.47 = 251970$ cub. ft.

Hence entire discharge through both channels will be $287829 + 251970 =$ 539799 cubic feet per second.

NOTE F (3).

ELEVATION OF SOUTH CHANNEL IN ORDINARY WINTERS WHILE ICE IS SHOVING AND THIS CHANNEL CHARGED WITH THE ENTIRE RIVER.

Let x = the mean depth at such a time then we get note F (2)

$$* 251970 : 539799 :: 15.87 \times \left(\frac{15.67}{2}\right)^{\frac{1}{2}} : x \times \left(\frac{x}{2}\right)^{\frac{1}{2}}$$

The resolution of this equation gives $x = 26.03$ ft.

Hence p. note B (3) we have $98.75 - 1.76 + 26.03 = 123.02$ feet.

This would be the elevation above datum to which the water would rise in the South Channel during ordinary winters, if the proposed scheme were in operation and the sluices all closed.

* Note—This should be diminished by the discharge from the canal, but there being no navigation at this season, the quantity is too insignificant to be noticed.

NOTE F (4)

ELEVATION OF HYDRAULIC AMPLITUDE AT LAPRAIRIE WHEN ELEVATION OF SOUTH CHANNEL IS 123.00 FEET.

Elevation at Section.....	123.02 ft.
do Nov. 24th, 1882.....	98.75 "
Increase of height.....	24.27 "

Difference of Level between section line and surface of water at Laprairie Nov. 24th 1882.. ..... = 9.85 ft.

Hence if we call y the height of the amplitude at Laprairie above the surface of the River there, before the rising of the water, we get per St. Guilheim's Theorem.

$$\frac{(24.27)^3}{(24.27)^3 + 0.1355\,(9.355)^3} + (9.85)^3 = (y + 9.85)^3$$

The resolution of this equation gives $y = 14.90$ ft.

Hence elevation at Laprairie = 108.60 + 14.90 = 123.50 ft. This will be the elevation of the water above datum at Laprairie during ordinary years while the ice is shoving.

The elevation of John street in front of Poissant's Hotel Laprairie is 121.88 ft.

NOTE G (1)

CONDITION OF BOTH CHANNELS WHILE THE ICE WAS SHOVING IN THE YEAR 1869.

Elevation of water at sill of lock	121.41 ft.
Difference of elevation at high water between water on sill and water at section, current St. Mary	1.59 "
Elevation at Current St. Mary	119.82 "

During high water, the elevations at the sections in St. Mary's Current and South Channel, are found to be equal. Hence elevation at South Channel is = 119.82 ft.

This was the maximum spring elevation in the year 1869, at these localities, which caused the shoving of the ice.

Let us now investigate the lemma of finding the discharges through both channels when the river was at this elevation.

St. Mary's current (see section):

Sectional area	109841 sq. ft.
Wetted perimeter	2594 ft.
Water line	2545 ft.
Hydraulic depth	42.34 ft.
Mean depth	43.16 ft.

South Channel (see section):

Sectional area	60239 sq. ft.
Wetted perimeter	3611 ft.
Water line	3610 ft.
Water line when works are built	3000 ft.
Hydraulic depth	18.06 ft.
Mean depth	18.06 ft.
Hydraulic depth (works being built)	21.74 ft.
Mean depth, do	21.74 ft.

NOTE (G) 2

DISCHARGES THROUGH BOTH CHANNELS DURING FLOOD OF 1869, ELEVATION BEING 119.82.

Current St. Mary.

Admitting the river to be open when elevation was at 119.82 we get per notes A & G $\sqrt{29.33} : \sqrt{42.34} :: 5.65 : x = 6.78$ ft. per sec.

This would be the velocity if river were open and elevation at 119.82 ft.

But being covered with ice this velocity becomes $\frac{6.78}{2} = 3.39$ ft. p. sec.

Hence Note G (1) Discharge $= 109841 \times 3.39 = 372361$ cub. ft. p. sec.

South Channel.

Admitting as above, the river to be open when its elevation was at 119.82 we get notes B. & G.

$\sqrt{1.76} : \sqrt{18.06} :: 3.65 : 11.69$ = velocity under such circumstances.

But being covered with ice this becomes $\frac{11.69}{2} = 5.84$.

Hence discharge $= 65239 \times 5.84 = 380996$ cub. ft. p. sec.

Entire discharge of river will therefore be $372361 + 380996 = 753357$ cub. ft. p. second.

There being no navigation at that season, the discharge from the canal may be neglected for all practical purposes.

NOTE G (3)

ELEVATION OF RIVER DURING THE FLOOD OF THE YEAR 1869, IF ALL THE WATER WERE MADE TO PASS THROUGH THE SOUTH CHANNEL AND LEVEES BUILT CONFINING IT TO A WIDTH OF 3000 FEET.

It will be seen in Note G (1) that on the 22nd of April, 1869, the South Channel being 3000 feet wide had a mean depth of 21.74 feet and its discharge was 380996 cubic feet per second.

Let x = Mean depth of South Channel when entire river, or 753357 cubic feet per second is flowing through it.

Then we have

$$(380996)^{\frac{3}{2}} : (753357)^{\frac{3}{2}} :: 21.74 : x$$

Whence $x = 34.24$ feet.

Then Note B (3) we get

$$98.75 - 1.56 + 34.24 = 131.43 \text{ ft.}$$

From this it appears that the elevation of the water in the South Channel on the 22nd April, 1869, would be 131.43 feet above datum if the proposed scheme were then in existence and the sluices all closed in the proposed embankment.

DOMINION CANALS.

Register of the Direction of the Wind, and of the Depth of water on the Lower Sill of Lock No. One on the Lachine Canal, taken by the Lock-master every day at noon, for the month of January, 1882.

Days of the month	Depth of water. Feet.	Ins.	Direction of Wind.	Days of the month	Depth of water. Feet.	Ins.	Direction of Wind.
1	16	9	W.	17	25	4	W.
2	17	0	W.	18	25	6	S. W.
3		3	N. E.	19	26	6	N. E.
4	18	6	W.	20	27	9	N. E.
5	19	3	E.	21	27	9	N. E.
6	21	0	N. E.	22	29	2	W.
7	22	3	W.	23	31	6	W.
8	23	1	S. W.	24	33	9	W.
9	23	8	W.	25	33	8	N. E.
10	22	4	W.	26	32	11	S. W.
11	22	4	N. E.	27	33	10	N. W.
12	23	8	N. W.	28	32	8	N E.
13	23	8	N. E.	29	32	5	N. W.
14	24	3	W.	30	31	10	N. W.
15	24	6	W.	31	32	8	W.
16	24	10	W.				

PATRICK FITZPATRICK, Lockmaster.

DOMINION CANALS.

Register of the Direction of the Wind, and of the Depth of Water on the Lower Sill of Lock No. One on the Lachine Canal, taken by the Lockmaster every day at noon, for the month of February 1882.

Days of the month	Depth of water.		Direction of Wind.	Days of the month	Depth of water.		Direction of Wind.
	Feet.	Ins.			Feet.	Ins.	
1	32	0	N. E.	17	30	8	N.
2	32	3	W.	18	29	1	N. E.
3	32	6	N W.	19	28	7	E.
4	30	9	N. E.	20	28	2	E.
5	30	3	N. E.	21	28	3	E.
6	30	4	N. W.	22	28	1	N. E.
7	30	1	N. E.	23	28	3	N. E.
8	30	3	N. W.	24	28	10	N. E.
9	30	3	N. E.	25	28	10	S. W.
10	30	10	N. E.	26	28	10	S. W.
11	30	2	S. W.	27	29	5	N. E.
12	30	2	S. W.	28	29	3	S. E.
13	30	7	S. W.	29			
14	30	5	N. W.	30			
15	30	6	S. W.	31			
16	30	7	S. W.				

P. FITZPATRICK, Lockmaster.

DOMINION CANALS.

Register of the Direction of the Wind, and of the Depth of Water on the Lower Sill of Lock No. One on the Lachine Canal, taken by the Lockmaster every day at noon, for the month of March, 1882.

Days of the month	Depth of water.		Direction of Wind.	Days of the month	Depth of water.		Direction of Wind.
	Feet.	Ins.			Feet.	Ins.	
1	29	1	S. W.	17	27	5	N. E.
2	30	0	N. W.	18	27	1	East.
3	30	7	N. W.	19	27	8	N. W.
4	30	10	N. E.	20	27	8	N. W.
5	30	11	N. E.	21	27	6	N. E.
6	30	7	N. E.	22	27	4	N. E.
7	30	4	N. E.	23	27	9	West.
8	29	6	West.	24	27	9	West.
9	29	5	N. E.	25	27	3	West.
10	29	5	N. E.	26	27	7	S. W.
11	28	10	West.	27	27	5	S. W.
12	28	9	S. W.	28	27	8	West.
13	28	7	North.	29	28	1	S. W.
14	27	10	N. W.	30	29	2	N. W.
15	27	11	S. W.	31	31	3	N. W.
16	27	10	N. E.				

P. FITZPATRICK, Lockmaster.

DOMINION CANALS.

Register of the Direction of the Wind and of the Depth of Water on the Lower Sill of Lock No. One on the Lachine Canal, taken by the Lockmaster every day at noon, for the month of April, 1882.

Days of the month	Depth of water		Direction of Wind.	Days of the month	Depth of water.		Direction of Wind.
	Feet.	Ins.			Feet.	Ins.	
1	31		S. W.	17	19	5	N. W.
2	32		N. E.	18	19	4	N. E.
3	29	1	N. E.	19	19	7	S. E.
4	28	9	W.	20	19	11	N. E.
5	25	9	N. E.	21	20	6	N. E.
6	24	5	N. E.	22	20	6	N.
7	23	6	W.	23	20	7	N. E.
8	23	5	N. E.	24	20	5	N. E.
9	23	1	N. E.	25	20	8	West.
10	22	3	S. E.	26	20	4	East.
11	21	3	N. W.	27	20	4	N. E.
12	20	6	W.	28	20	2	S. E.
13	20	3	N. W.	29	20	1	S.
14	19	11	N. W.	30	20	2	S.
15	19	8	N. W.	31			
16	19	6	N. W.				

P. FITZPATRICK, Lockmaster.

DOMINION CANALS.

Register of the Direction of the Wind, and of the Depth of Water on the Lower Sill of Lock No. One on the Lachine Canal, taken by the Lock-master every day at noon, for the month of May, 1882.

Days of the month	Depth of water.		Direction of Wind.	Days of the month	Depth of water.		Direction of Wind.
	Feet.	Ins.			Feet.	Ins.	
1	20	2	W.	17	21	5	N. E.
2		5	N. W.	18		7	E.
3		4	W.	19		6	E.
4		5	N. W.	20		7	S. E.
5		5	E.	21		8	N. E.
6		4	S. W.	22		8	N. E.
7		3	S. W.	23	22	0	S. E.
8		2	S. E.	24		1	N. W.
9		4	N. E.	25		3	E.
10		4	N. E.	26		2	W.
11		7	S. W.	27		5	W.
12		6	S. E.	28		9	N. E.
13		6	S.	29		8	N.
14		8	N. E.	30		7	W.
15	21	3	N. E.	31		9	S.
16		3	S. W.				

PATRICK FITZPATRICK, Lockmaster.

DOMINION CANALS.

Register of the direction of the wind, and of the depth of water on the Lower Sill of Lock No. One on the Lachine Canal, taken by the Lock-master every day at noon, for the month of June, 1882.

Days of the month	Depth of water.		Direction of Wind.	Days of the month	Depth of water.		Direction of Wind.
	Feet.	Ins.			Feet.	Ins.	
1	22	11	W.	17	22	4	N.
2	22	10	S. W.	18	22	3	N. W.
3	23	1	W.	19	22	4	W.
4	23	3	W.	20	22	3	[illegible]
5	23	5	W.	21	22	3	S. W.
6	23	6	S. W.	22	22	2	S.
7	23	5	S. W.	23	22	1	S. W.
8	23	5	S. W.	24	22	1	S. E.
9	23	4	N. W.	25	21	11	W.
10	23	4	S. W.	26	21	11	S. W.
11	23	2	N. W.	27	21	11	N. W.
12	22	11	N.	28	21	11	N. W.
13	22	10	S. W.	29	21	11	N. W.
14	22	7	S.	30	21	8	S. W.
15	22	6	S. W.	31			
16	22	4	N E.				

PATRICK FITZPATRICK, Lock-master.

DOMINION CANALS.

Register of the Direction of the Wind, and of the Depth of Water on the Lower Sill of Lock, No. One, on the Lachine Canal, taken by the Lock-master every day at noon, for the month of July, 1882.

Days of the Month	Depth of Water.		Direction of Wind.	Days of the Month	Depth of Water.		Direction of Wind.
	Feet.	Ins.			Feet.	Ins.	
1	21	8	E.	17	20	4	S.
2		7	N. W.	18		2	S.
3		9	W.	19		3	S. W.
4		8	E.	20		1	W.
5		9	N. W.	21	20	0	W.
6		9	N.	22	19	11	S. W.
7		6	W	23		9	W.
8		5	W.	24		8	S. W.
9		3	S. W.	25		6	S. W.
10		2	S.	26		6	S. W.
11	21	0	S. W.	27		7	N. E.
12	20	10	W.	28		7	E.
13		11	S. W.	29		8	N. E.
14		10	W.	30		8	E.
15		7	W.	31	19	9	N. E.
16		6	S.				

P. FITZPATRICK, Lockmaster.

DOMINION CANALS

Register of the Direction of the Wind, and of the Depth of Water on the Lower Sill of Lock No. One on the Lachine Canal, taken by the Lockmaster every day at Noon, for the Month of August 1882.

Days of the month	Depth of water.		Direction of Wind.	Days of the month	Depth of water.		Direction of Wind.
	Feet.	Ins.			Feet.	Ins.	
1	19	8	E.	17	18	11	W.
2		7	S. E.	18	19	1	"
3		7	N. E.	19		1	N. W.
4		4	W.	20		2	N. E.
5		3	W.	21		1	W.
6		2	W.	22		2	N. W.
7		2	S. W.	23		2	S. W.
8		0	East	24		3	W.
9		1	W.	25		3	N. E.
10		0	N. E.	26		3	E.
11	19	0	S. W.	27		2	N. E.
12	18	10	S. W.	28		1	E.
13		11	West	29	19	0	N. E.
14		10	S.	30	19	0	N. W.
15	18	11	N. W.	31	18	11	S. W.
16	19	0	N. W.				

P. FITZPATRICK, Lockmaster.

DOMINION CANALS.

Register of the Direction of the Wind, and of the Depth of Water on the Lower Sill of Lock No. One on the Lachine Canal, taken by the Lockmaster every day at noon, for the month of September, 1882.

Days of the month	Depth of water.		Direction of Wind.	Days of the month	Depth of water.		Direction of Wind.
	Feet.	Ins.			Feet.	Ins.	
1	19		S. W.	17	18	3	W.
2	18	11	E.	18	18	2	N. E.
3	18	10	W.	19	18	1	N. E.
4	18	10	S. W.	20	18	5	N. E.
5	18	11	N. E.	21	18	5	N. E.
6	18	9	N. E.	22	18	4	S.
7	18	7	W.	23	18	6	S.
8	18	7	N. E.	24	18	7	W.
9	18	6	N. E.	25	18	7	N. E.
10	18	5	N. W.	26	18	7	N. E.
11	18	6	N. E.	27	18	8	E.
12	18	6	W.	28	18	7	E.
13	18	3	S. W.	29	18	8	N. E.
14	18	0	S.	30	18	9	N. E.
15	18	3	N. W.	31			
16	18	4	W.				

P. FITZPATRICK, Lockmaster.

DOMINION CANALS.

Register of the Direction of the Wind, and of the Depth of Water on the Lower Sill of Lock No. One on the Lachine Canal, taken by the Lock-master every day at noon, for the month of October, 1882.

Days of the month	Depth of water.		Direction of Wind.	Days of the month	Depth of water.		Direction of Wind.
	Feet	Ins.			Feet.	Ins.	
1	18	7	N. W.	17	17	7	W.
2	18	8	N. W.	18	17	6	W.
3	18	5	West.	19	17	5	N. E.
4	18	1	West.	20	17	5	N.
5	18	0	N. E.	21	17	3	W.
6	17	10	N. E.	22	17	1	S.
7	17	10	N. W.	23	17	1	S. W.
8	17	6	S. W.	24	17	3	W.
9	17	6	W.	25	17	3	W.
10	17	7	S. E.	26	17	3	W.
11	17	6	W.	27	17	2	W.
12	17	6	S. E.	28	17	3	E.
13	17	5	S.	29	17	1	S. W.
14	17	5	W.	30	17	2	S. W.
15	17	7	W.	31	17	2	S. W.
16	17	8	N. E.				

PATRICK FITZPATRICK, Lock-master.

DOMINION CANALS

Register of the Direction of the Wind, and of the Depth of Water on the Lower Sill of Lock No. One on the Lachine Canal, taken by the Lockmaster every day at Noon, for the month of November 1882.

Days of the month	Depth of water.		Direction of Wind.	Days of the month	Depth of water.		Direction of Wind.
	Feet.	Ins.			Feet.	Ins.	
1	17	3	West	17	17	6	N. E.
2	17	2	"	18	17	6	"
3	17	2	S. W.	19	17	7	N. W.
4	17	3	East	20	17	6	"
5	17	1	N. E.	21	17	4	West.
6	17	11	"	22	17	6	N. E.
7	16	9	South	23	17	4	West.
8	16	10	N. E.	24	17	6	"
9	16	10	West	25	17	7	S. W.
10	16	11	N. E.	26	17	8	West.
11	17	0	South	27	17	5	"
12	17	1	N. E.	28	17	4	"
13	17	2	"	29	17	1	N. W.
14	17	3	N. W.	30	17		West.
15	17	4	"	31			
16	17	5	West				

P. FITZPATRICK, Lockmaster.

DOMINION CANALS.

Register of the Direction of the Wind, and of the Depth of Water on the Lower Sill of Lock, No. One, on the Lachine Canal, taken by the Lockmaster every day at noon, for the month of December, 1882.

Days of the Month	Depth of Water.		Direction of Wind.	Days of the Month	Depth of Water.		Direction of Wind.
	Feet.	Ins.			Feet.	Ins.	
1	16	11	W.	17	22	3	W.
2	16	11	N E.	18	23	1	W.
3	16	10	N. E.	19	24	9	W.
4	16	7	N. E.	20	26	0	E.
5	16	6	S. W.	21	27	3	N. E.
6	16	6	W.	22	28	1	N. E.
7	16	7	S. W.	23	30	2	W.
8	16	9	W.	24	30	0	W.
9	16	11	S. W.	25	29	3	N. W.
10	17	6	N. E.	26	28	4	E.
11	18	1	N. E.	27	28	11	N.
12	18	5	N. E.	28	28	6	W.
13	18	7	S W.	29	28	9	W.
14	19	1	S. E.	30	29	1	W.
15	20	0	W.	31	28	9	W.
16	21	2	W.				

F. FITZPATRICK, Lockmaster.

PORT OF MONTREAL.

MEMORANDUM TAKEN FROM THE HARBOR MASTER'S REPORTS GIVING THE DATES OF THE OPENING AND CLOSING OF NAVIGATION FROM 1864 TO DEC. 31st 1881.

1864.—The ice in the harbor began to break and move on the 7th of April, on the 13th, river was clear, close of navigation Dec. 10th.

1865.—On the 1st of January the water gradually rose, on the 14th the ice shoved, on the 15th the ice remained stationary.

1866.—Opening of navigation April 19th, on the 5th January, 1866, the river was full of ice, on the 6th the ice become stationary.

1867.—On the 1st January the water was level with the wharves, ice forming fast, on the 9th ice became stationary. The first shove of the ice took place on the 14th April, on 22nd the harbor was clear of ice.

1868.—The winter was unusually cold, the river was frozen at an early date, teams crossed on the 16th Dec., 1867, on the 19th March, 1868, ice shoved, on the 4th April the ice shoved heavily opposite the city, on the 14th and 15th the ice kept moving, on the 17th the harbor was clear.

1869.—Dec. 28th, the river was frozen over early, on this date the first team crossed to St. Lambert, in the beginning of 1869 the ice was considered firm for the winter, on the 13th April the ice shoved, on the 18th shoved again, on the 19th it shoved, flooding Griffintown, which continued until the 23rd, at 10 A. M. ice below gave way, on 25th the harbor clear of ice.

1870.—On the 1st January channel opposite city free of ice, on the 8th crossed on foot, on 9th ice shoved, no crossing until 13th, teams crossed on the 15th, on 17th thaw set in which lasted some time, on 31st March the ice opposite the city was bad, the first shove on the 9th April, shoved on 10th and 11th, on the 17th harbor clear of ice.

1871.—On the 4th January river frozen over, on 6th became mild, ice shoved, on 11th teams crossing, on 15th March a slight shove, 17th

shoved again, on 31st last crossing, 3rd April the ice kept moving, on 10th Harbor clear.

1872.—When the year commenced the river was frozen and teams crossing, on April 18th first shove, on 28th harbor clear, on 1st May vessels arrived in Port.

1873—On the 1st January the river was frozen over and ice stationary, teams crossing, on 11th April the ice shoved and continued to do so daily until the 21st when it gave way, on 25th Str. *William* arrived from Sorel.

1874.—On 17th January the river was frozen over, on 21st teams crossed from Longueuil, April 18th first shove, on 23rd harbor free from ice, 25th a number of small craft arrived in Port. The ice bridge at Cape Rouge held firm until the 9th of May.

1875.—On the 1st January the river opposite the city was full of ice, teams crossed below Hochelaga on the last day of the year 1874, on 4th January, 1875, ice became stationary. The winter was the coldest that had been experienced for many years. The first ice shoved on the 24th April, on 29th harbor clear, on the 1st May a May-Pole was placed on the ice opposite Longueuil, on 3rd river vessels arrived from Boucherville, on the 7th ice-bridge at Cape Rouge gave way. On the 5th December ice became stationary, on 21st teams crossed to the city, the earliest on record.

1876.—When January commenced the river was frozen and ice good, on April 12th ice got bad, on 16th first shove and shoved daily until 26th, on 27th several vessels arrived from Boucherville. On 19th December the ice was good, persons crossing on foot, 23rd teams crossing.

1877.—When the year commenced the river was frozen over, the weather in April was fine and mild, on the 5th the ice began to get bad, on the 8th the first shove and moved downwards, on the 14th the channel was clear as far as Hochelaga, on the 17th the tug *Francis* arrived from Boucherville. The weather was mild this fall, the navigation was still open on the 31st of December.

1878.—On the first of January, the Longueuil Ferry still running, in the afternoon left the harbor with a party on a pleasure excursion to Boucherville, on the 17th people crossed the ice on foot, on 24th good crossing. The 7th of January was the coldest day of the winter, at 8 a.m. 15° below zero, on the 1st of February roads were made, on the 18th a road was made to Laprairie, and on the last day of the month

these roads were considered unsafe. March 1st cold snap, on the 2nd teams again crossed to St. Lambert and Laprairie, on the 12th again abandoned, on the 16th first open water, on 18th first shove of ice, on 22nd channel clear as far as Pointe-aux-Trembles, on the 29th the steamer *Montarville* came into the harbor but had to return to Boucherville, on the 30th tug *St. Francis* arrived in port; on the last day of the year the river was full of drift ice.

1879.—On the first of January the weather was fine, in the afternoon a boat's crew descended the Lachine Rapids in safety, on the 25th the river was full of ice, on 26th teams crossed at Longueuil, on the 1st February a road was made from St. Lambert, on 13th February a road was made from Laprairie, on the 12th of April the ice shoved, after the 15th the ice kept daily moving downwards, on the 18th the ice became so closely packed and stationary that people crossed on foot, on 23rd steamer *St. Lambert* arrived in port from Boucherville. On the 22nd December it was very cold, 22° below zero, on the 25th river full of ice, on 27th crossing on foot, teams crossing at Longueuil.

1880.—On the 1st of January weather fine, at 8 A.M. 4° below zero, river opposite city full of ice, teams crossing below Longueuil; on the 2nd crossing on foot to St. Lambert; on the 13th commenced laying a Railroad track on the ice from Hochelaga to Longueuil, completed on the 30th; on the following day the road was opened; on the 1st of April ice began to get bad, on the same day a commencement was made to remove the ice-bridge Railroad; April 5th first shove of the ice; on the 6th ice shoved again; on the 7th a very heavy shove on Island Mouton, it was piled up 44 feet, the water in the harbor at that time was 17 feet above the summer level; on the 13th a large quantity of ice left the harbor; on the 17th river craft arrived from Boucherville; on the 29th of April the ice bridge at Cape Rouge gave way; on the 3rd of December the river was full of ice, Longueuil Ferry left for winter quarters; on the 29th roads were commenced on the ice to St. Lambert.

1881.—The New Year commenced with fine weather. On the 5th Railway cars commenced crossing at Longueuil; on the 8th of April, the ice commenced breaking up; 13th, channel opposite city clear; on 19th, tug *C. W. Francis* arrived in port, being the first arrival of the season; on the 27th, SS. *Peruvian* arrived from Sorel where she had wintered; Dec. 31st, fine mild weather; the year closed with open navigation, the *Longueuil* making regular trips.

THOMAS HOWARD,
Harbor Master.